Public Safety Distributed Antenna Systems

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CTO

AGENDA

- About Us
- What is a DAS?
- Spectrum for Public Safety
- Code vs Non-Code
- Capacity
- Link Budget and Coverage
- Amplifier Oscillation
- Differential Delay
- Passive Intermodulation (PIM)
- Sharing with Commercial DAS
- Maintenance and Monitoring
- Key Take-Aways

ABOUT US

Longent LLC founded in 2001

- Headquartered in Raleigh NC
- 3,000+ completed projects
- Licensed Contractor (AL, MS, TN, VA, WV, NC, SC, GA, FL)

Engineering Department:

- Degreed engineers and certified/degreed technicians

Operations Department:

- PMP Certified Program Managers
- In-house Installation Technicians
- In-House Training Lab

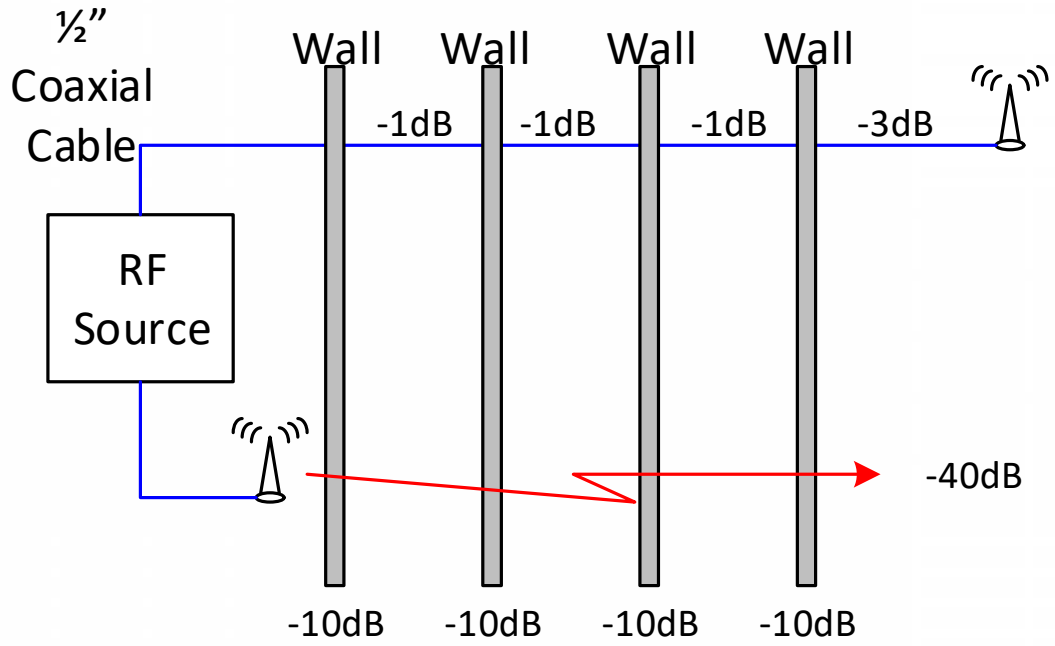
Customer Support:

- 24/7 Network Operations Center

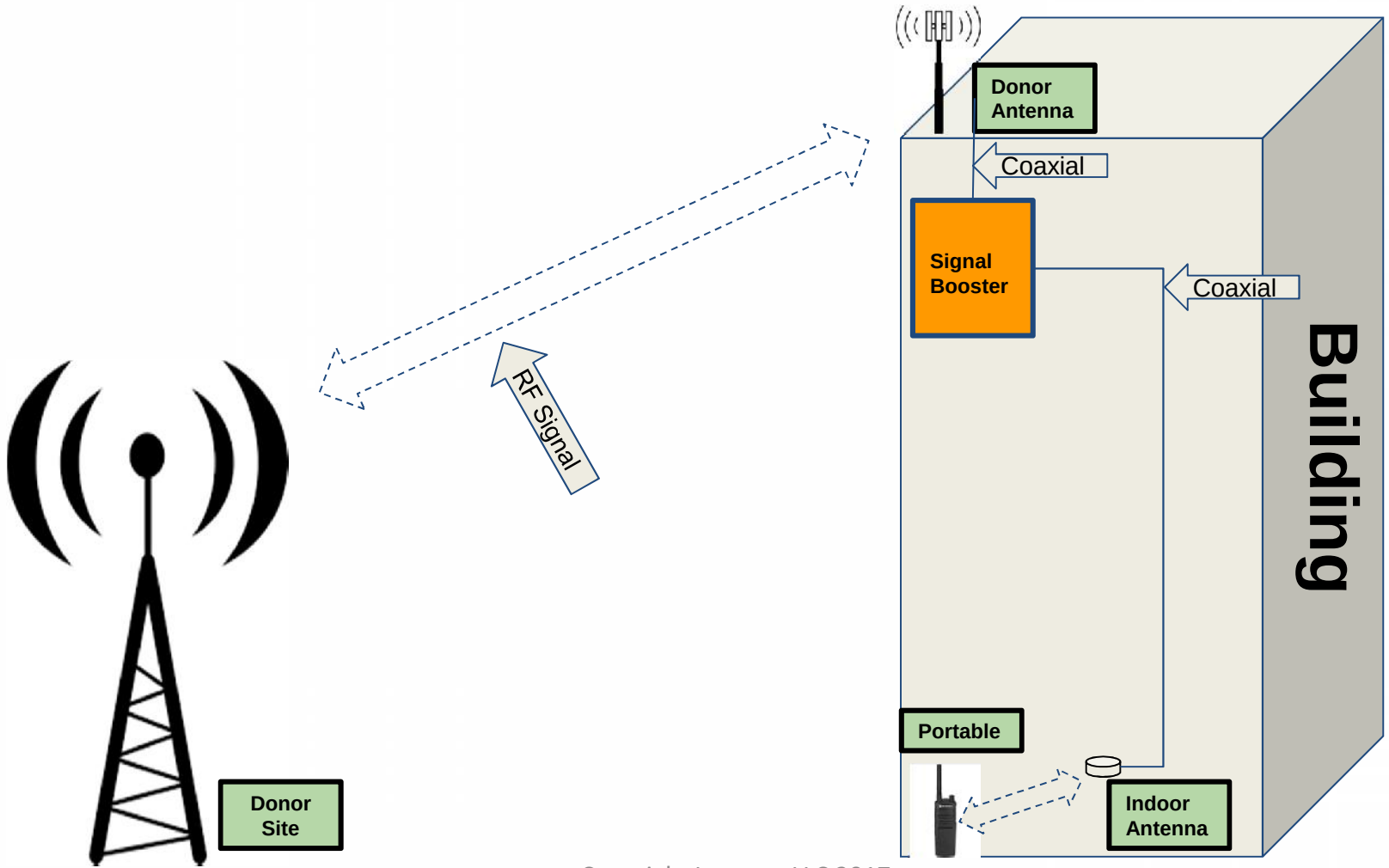
What is a DAS

DAS = Distributed Antenna System

BECAUSE……Coax is more efficient through Walls

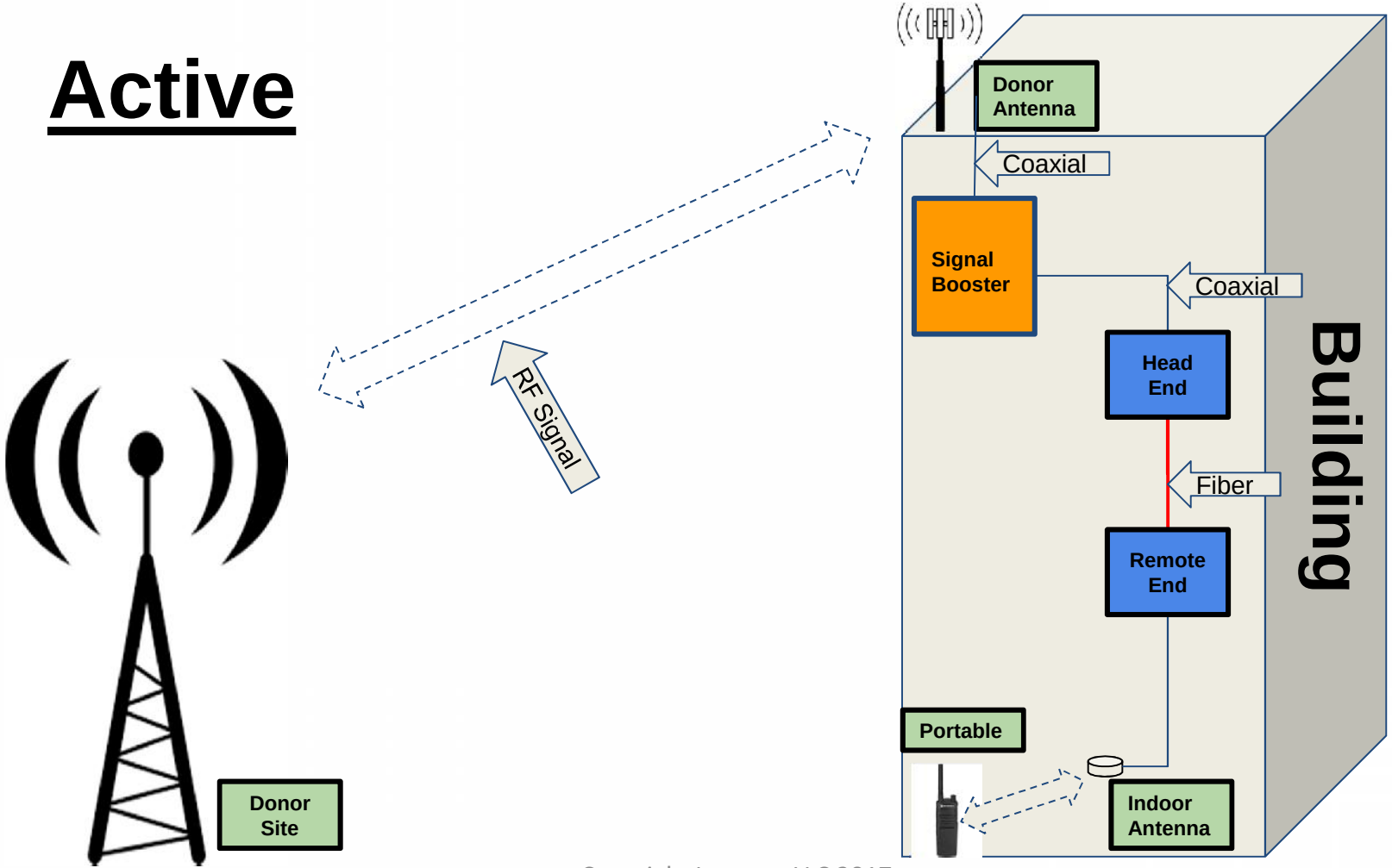


Passive DAS



Active DAS

Active



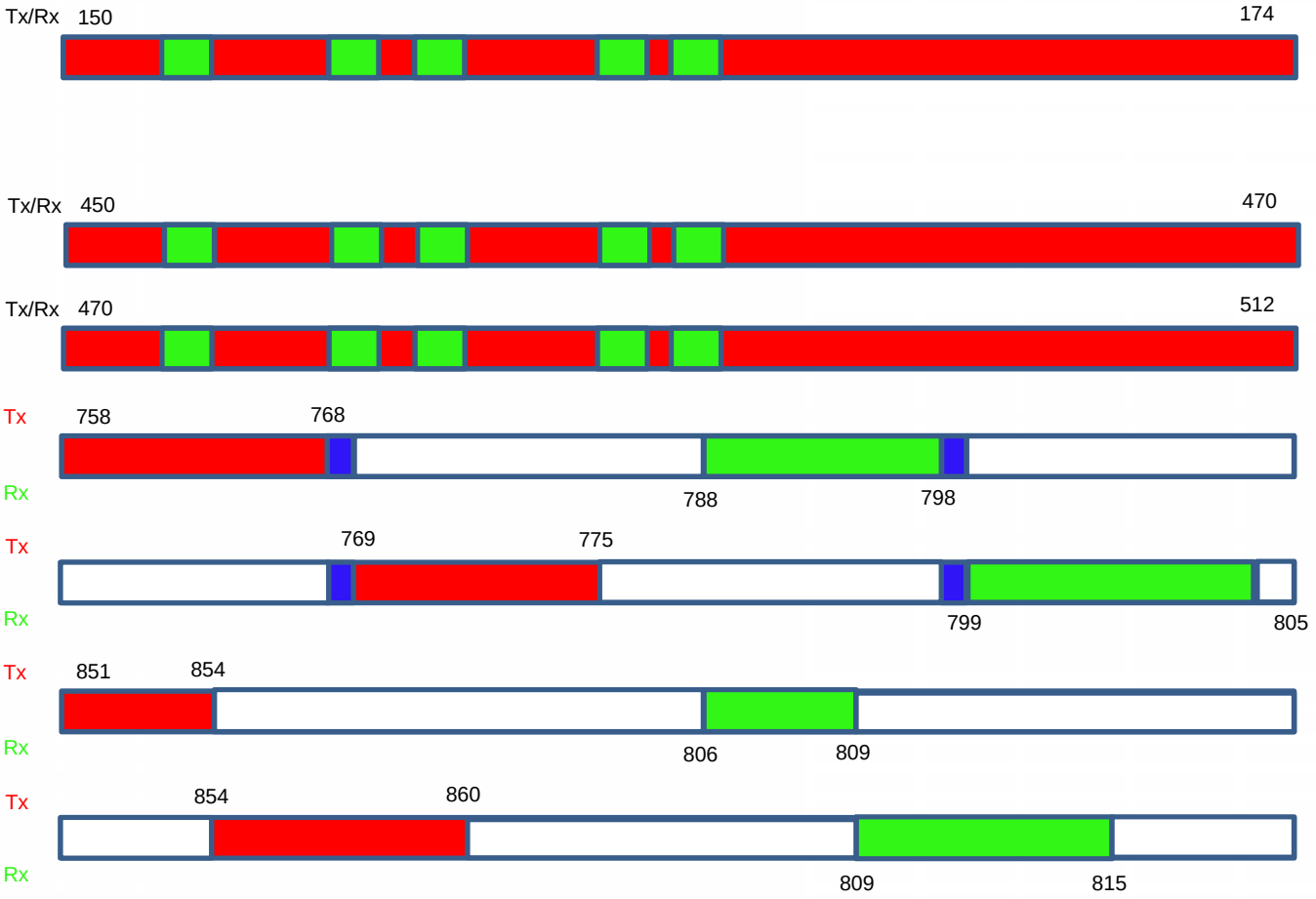
Active vs Passive DAS

- Size or Building Construction
  - Too BIG for one Repeater(Booster, Amplifier,BDA)
  - Too DIFFICULT for routing Coax (Atriums, Hard Ceilings, Low Plenum)
- Repeaters are usually 1/2W, 1W, 2W, or 5W
- Capacity Calculation + Coverage +Max output = Repeater Choice
- ACTIVE DAS is Scalable / More Flexible
  - Cost much more (Still need Repeater + Cost of Active DAS)
  - Uses Fiber to distribute signal to DAS Remotes—then back to RF.

Public Safety Spectrum

Frequency	MHz Available for Public Safety
25-50 MHz (VHF Low Band)	6.3 MHz
150-174 MHz (VHF High Band)	3.6 MHz [non contiguous]
220-222 (220 MHz band)	0.1 MHz
450-470 (UHF Band)	3.7 MHz [non-contiguous]
470-512 MHz (T-Band)	6 to 12 MHz blocks [contiguous in specified markets]
758-769/788-799 MHz (700 Broadband)	22 MHz (11 MHz x 11 MHz) [contiguous]
768-775/798-805 (700 Narrowband)[1]	14 MHz (7 MHz x 7 MHz) [contiguous]
806-809/851-854 MHz (NPSPAC Band)	6 MHz (3 MHz x 3 MHz) [contiguous]
809-815/854-860 MHz (800 MHz Band)	3.5 MHz (1.75 MHz x 1.75 MHz) [non-contiguous]

Interleaved Spectrum = Trouble with DAS



DAS with UHF and VHF

- Interleaved Spectrum with TX and Rx causes CHALLENGES
- Repeaters ship with Separate TX and RX ports….both Serving and Donor Ports
- Separate Tx and Rx in Building
- Or Custom Duplexers!
  - Custom Duplexers do not accommodate changes to Frequency Plan
  - Significant cost and Possible system Downtime to Change Duplexers
- Separating Donor Antennas is Tricky

Code…..What Code?

- Emergency Responder Code Options
  - None
  - Locally Derived
  - International Fire Code Section 510
  - National Fire Protection Association 72
  - Hybrid Adoption with ER coverage removed

- The Code Year Matters
  - Significant changes have occurred with recent updates
  - Local adoption of specific clauses
  - New building may have had permit issued under previous code version

IFC Code

State of North Carolina to Adopt 2015 IFC with Section 510 in January 2018

Item	2009 IFC Section 510	2009 IFC Appendix J	2012 IFC Section 510	2015 IFC Sections 510 & 1103
Buildings Required	New		New	New & Existing per Fire Marshal
Coverage levels	DL 95% at -95dBm	Appendix J Not always adopted	DL 95% at -95dBm	DL 95% at -95dBm
	UL 95% at -100dBm		UL 95% at -95dBm	UL 95% at -95dBm
Active Enclosure Types	N/A	NEMA4 Enclosure	NEMA4 Enclosure	NEMA4 Enclosure
Battery requirements	N/A	NEMA4 Enclosure	NEMA4 Enclosure	NEMA4 Enclosure
Battery run time	N/A	12 hours	24 hours	24 hours
RF testing proceedure	N/A	Grid Test	Grid Test	Grid Test
Monitoring	N/A	Alarm on Fault	Electronically Monitored and Audible Alert at Staffed NOC	Electronically Monitored and Audible Alert at Staffed NOC
Annual Maintenance	N/A	Grid and Battery Test	Grid and Battery Test	Grid and Battery Test
Freq Changes	N/A	Building Owner Must Comply	Building Owner Must Comply	Building Owner Must Comply
System Design	N/A	Design must be approved by Fire Code official prior to installation	Design must be approved by Fire Code official prior to installation	Design must be approved by Fire Code official prior to installation

NFPA 72

- Not used in North Carolina

- Requirements are somewhat different from IFC
  - 12hour Battery Run Time
  - Fire Engine Red Paint
  - Delivered Audio Quality of 3.0
  - Riser Cables in 2 hour rated enclosure
  - Several additional items….

Capacity

- Amplifiers have limited power that must be shared!
  - Applies to both DAS and Repeater Amplifier
- How Many Channels do we support during Emergency!?

	1/2W	1/2W	1/2W	
Max Repeater Tx Power	27	27	27	dBm
Channels	1	6	24	Channels
DeRating	0.0	7.8	13.8	dB
Max Per Channel Output Power	27.0	19.2	13.2	dBm
Other Energy in Filter Passband	3	3	3	dB
Net Output Power per Channel	**24.0**	**16.2**	**10.2**	dBm

Link Budget and Coverage

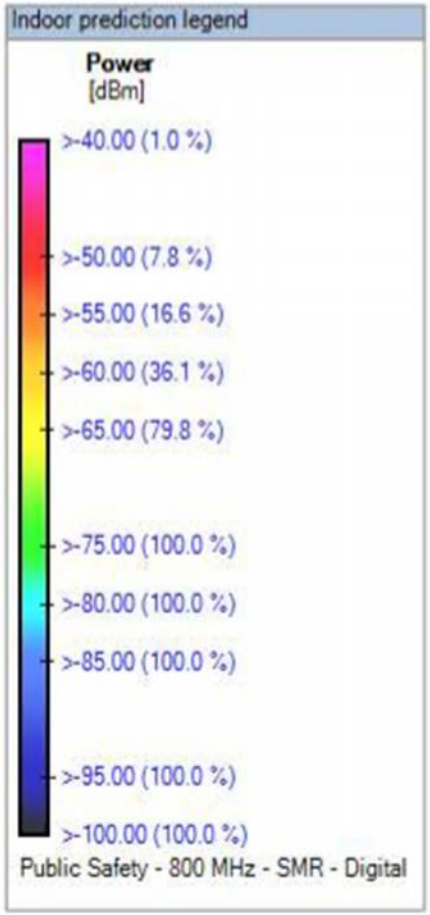
* Excluding Antenna Gain and Cable Losses

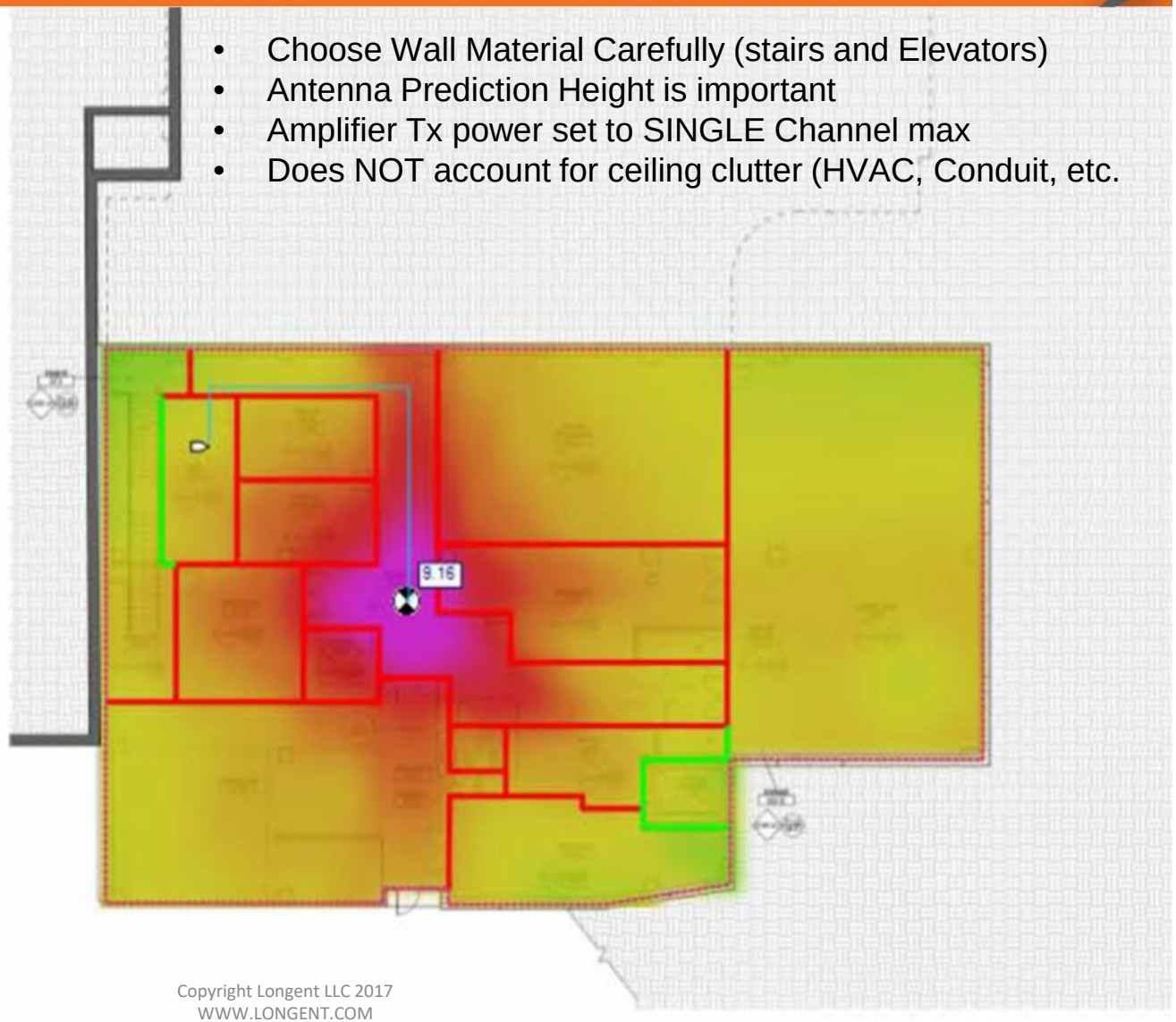
- PS DAS systems are DL Limited
  - Typical PS DAS Antenna Tx Level is 0 to -5dBm per Channel
  - Coverage requirement is -95dBm or better
  - That gives us ~ 90 - 95dB of Path loss on DL

- UL Path Loss budget is bigger.
  - Portable Tx = 3W (34.8dBm), 5W (37dBm), or 6W (37.8) depending on Band
  - 34dBm – (-90dB) Min Rx Level = 124dB Path loss on UL

RF Coverage Prediction

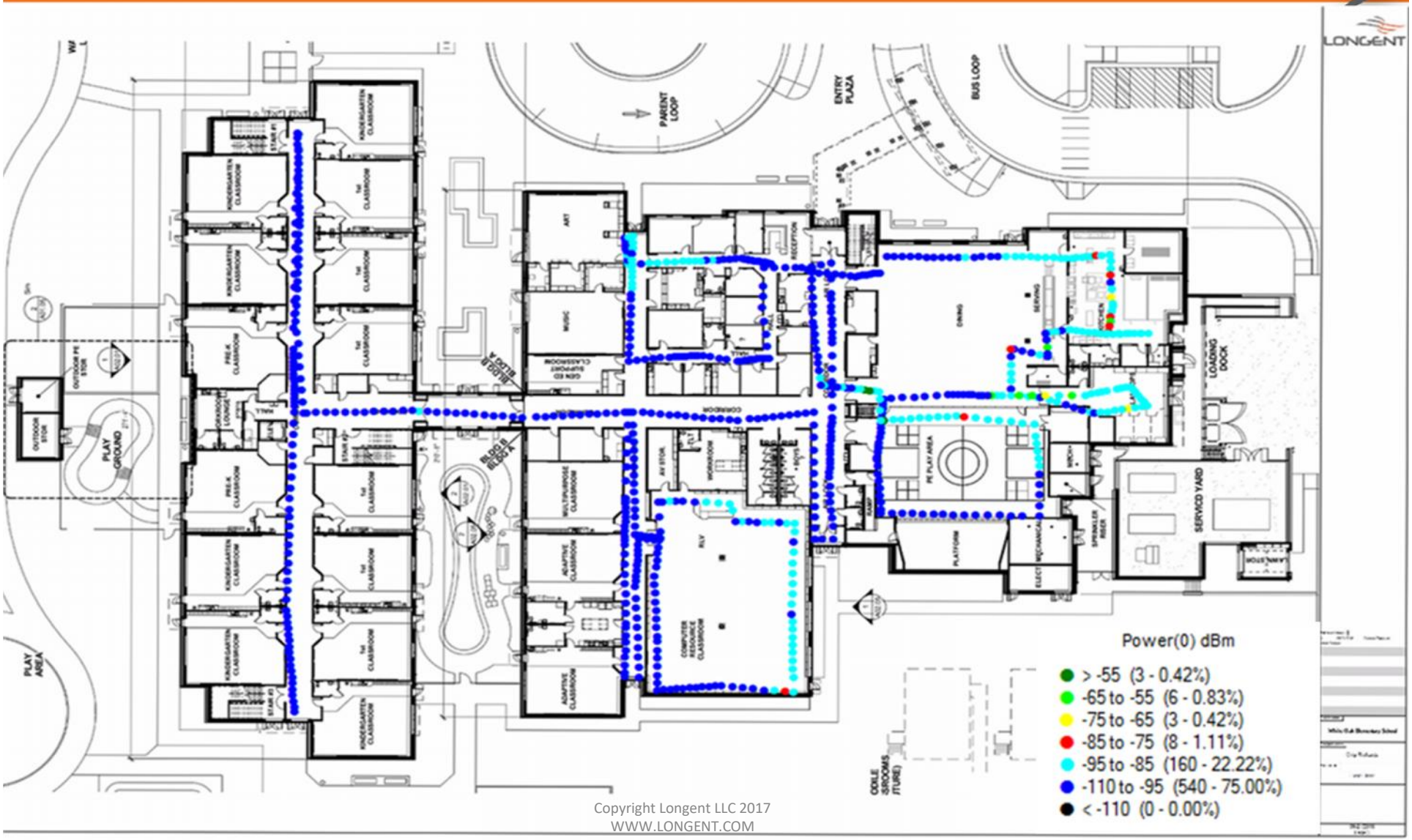
- Choose Wall Material Carefully (stairs and Elevators)
- Antenna Prediction Height is important
- Amplifier Tx power set to SINGLE Channel max
- Does NOT account for ceiling clutter (HVAC, Conduit, etc.



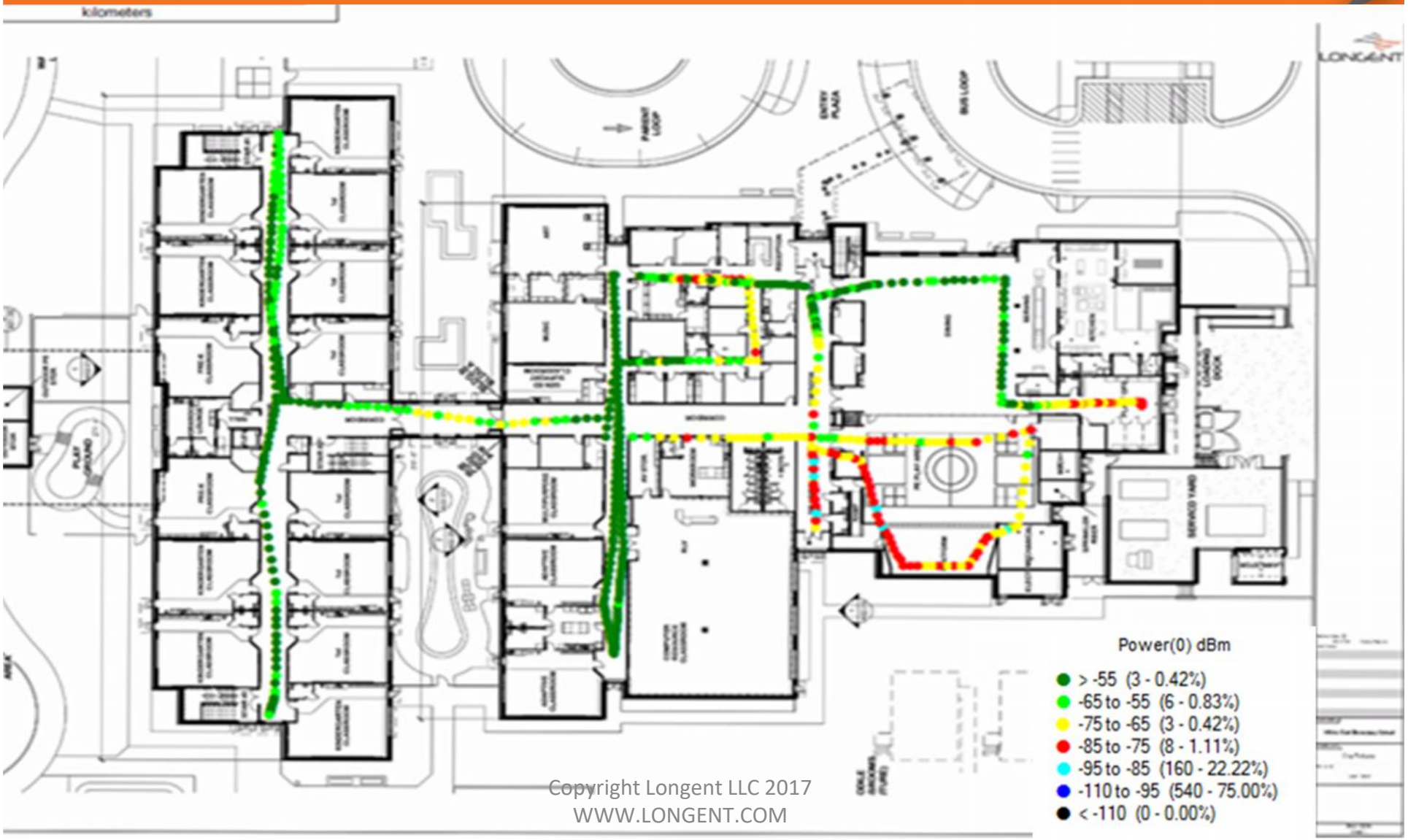


RF Mapping- Site Survey- Before

Why Benchmark before DAS?

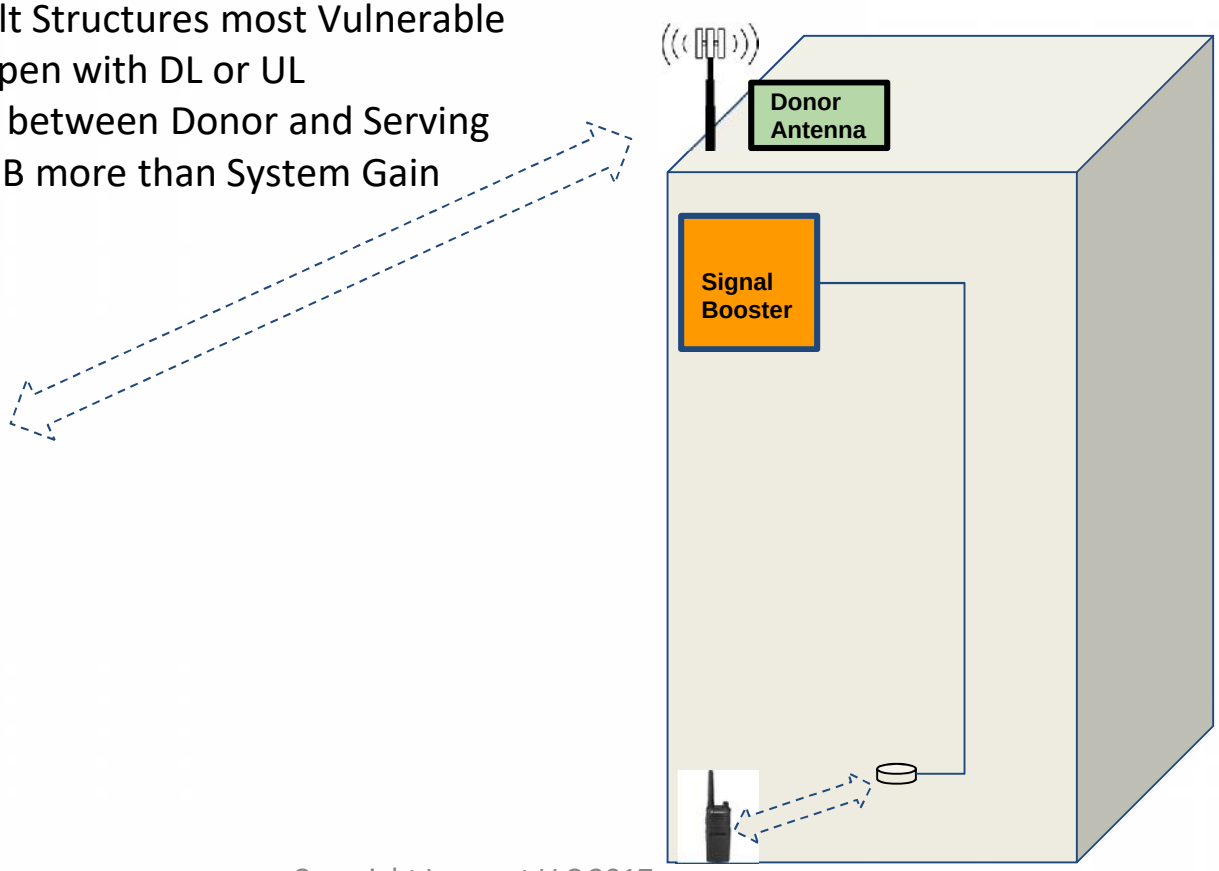


RF Mapping- Site Survey- After



Oscillation for lack of Isolation….

- A common Problem with Repeater fed systems
  - Microphone feedback
  - Stick Built Structures most Vulnerable
  - Can Happen with DL or UL
  - Pathloss between Donor and Serving
    - 15dB more than System Gain

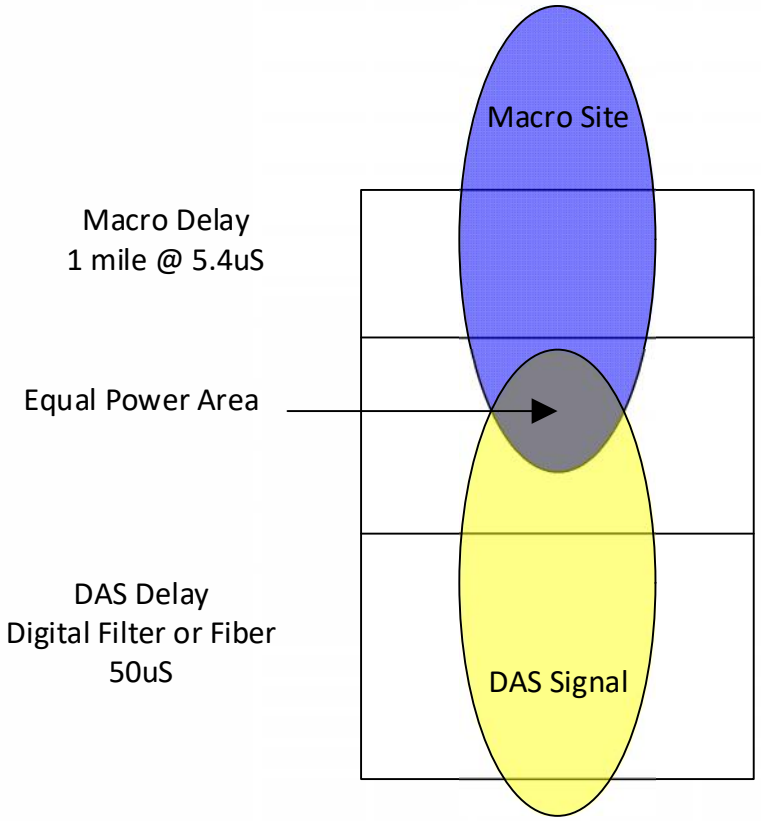


Oscillation Mitigation

- Choose Repeater with Oscillation Detection
  - Reduces Gain until Pathloss equation is solved
  - That means less coverage
- Choose good Donor Antenna
  - Narrow Beam Panel Antenna
  - High Front to Back Ratio
  - Mounted on Edge of Building
    - Do NOT aim across or into building being served
- Make sure serving antennas cannot “see” donor
  - Add structure for Path Loss
  - Walls, Roof, stairwells, and Elevators are good.
  - Windows are not your friend
- RF Absorbing Blankets
  - In a Pinch

Differential Delay

- Too Much Delay in DAS causes quality problems
  - P25 Phase I Max = 60uS
  - P25 Phase II Max = 48uS
  - DAQ 3.0 requires <31uS
- Delay Sources
  - Narrow Digital Filters
    - Class A Amplifiers
  - Very Long Fiber
    - 7.9uS per mile for SMF-28e



Passive Intermodulation (PIM)

- PIM
  - Frequency Artifacts that occur with Non-Linear Mixing
  - 3rd Order Intermod --→ 2a - b
- Internal PIM Sources
  - Loose Connectors
  - Damaged Cable
  - Poorly Prepared Connectors
  - Non-PIM rated components (couplers, splitters, antennas) (MOST EXISTING SYSTEMS!)
- External PIM Sources
  - Rusty sheet metal or nuts and bolts
  - Roof Flashing
  - Ceiling Tile Grid Wire
  - Steel Wool

- CAN cause interference to Uplink spectrum and overwhelm desired signal

PIM Caution – Firstnet

PIM Intermod Studies

700NB + 800 NB

********In order 3: 1000 products checked, 0 hits found.

********In order 5: 33649 products checked, 0 hits found.

700NB + 700 BB

********In order 3: 1140 products checked, 42 hits found.

775.000000 involved in 20 hit(s)	= 47.62%
775.000000 involved in 20 hit(s)	= 47.62%
758.000000 involved in 15 hit(s)	= 35.71%
774.000000 involved in 14 hit(s)	= 33.33%
759.000000 involved in 11 hit(s)	= 26.19%
773.000000 involved in 9 hit(s)	= 21.43%
760.000000 involved in 8 hit(s)	= 19.05%
761.000000 involved in 5 hit(s)	= 11.90%
772.000000 involved in 5 hit(s)	= 11.90%
762.000000 involved in 3 hit(s)	= 7.14%
771.000000 involved in 2 hit(s)	= 4.76%

********In order 5: 26334 products checked, 9345 hits found.

775.000000 involved in 3424 hit(s)	= 36.64%
775.000000 involved in 3424 hit(s)	= 36.64%
774.000000 involved in 3137 hit(s)	= 33.57%
773.000000 involved in 2836 hit(s)	= 30.35%
758.000000 involved in 2662 hit(s)	= 28.49%
772.000000 involved in 2539 hit(s)	= 27.17%
759.000000 involved in 2454 hit(s)	= 26.26%
771.000000 involved in 2261 hit(s)	= 24.19%
760.000000 involved in 2238 hit(s)	= 23.95%
761.000000 involved in 2033 hit(s)	= 21.75%
770.000000 involved in 2020 hit(s)	= 21.62%
762.000000 involved in 1850 hit(s)	= 19.80%
763.000000 involved in 1700 hit(s)	= 18.19%
768.000000 involved in 1651 hit(s)	= 17.67%
764.000000 involved in 1575 hit(s)	= 16.85%
767.000000 involved in 1543 hit(s)	= 16.51%
765.000000 involved in 1506 hit(s)	= 16.12%
766.000000 involved in 1496 hit(s)	= 16.01%

700NB + 700 BB + 800NB

********In order 3: 4960 products checked, 42 hits found.

775.000000 involved in 20 hit(s)	= 47.62%
775.000000 involved in 20 hit(s)	= 47.62%
758.000000 involved in 15 hit(s)	= 35.71%
774.000000 involved in 14 hit(s)	= 33.33%
759.000000 involved in 11 hit(s)	= 26.19%
773.000000 involved in 9 hit(s)	= 21.43%
760.000000 involved in 8 hit(s)	= 19.05%
772.000000 involved in 5 hit(s)	= 11.90%
761.000000 involved in 5 hit(s)	= 11.90%
762.000000 involved in 3 hit(s)	= 7.14%
771.000000 involved in 2 hit(s)	= 4.76%

********In order 5: 278256 products checked, 21000 hits found.

775.000000 involved in 7298 hit(s)	= 34.75%
775.000000 involved in 7298 hit(s)	= 34.75%
774.000000 involved in 6349 hit(s)	= 30.23%
773.000000 involved in 5449 hit(s)	= 25.95%
758.000000 involved in 5248 hit(s)	= 24.99%
759.000000 involved in 4663 hit(s)	= 22.20%
772.000000 involved in 4620 hit(s)	= 22.00%
760.000000 involved in 4095 hit(s)	= 19.50%
771.000000 involved in 3879 hit(s)	= 18.47%
761.000000 involved in 3571 hit(s)	= 17.00%
770.000000 involved in 3248 hit(s)	= 15.47%
762.000000 involved in 3104 hit(s)	= 14.78%
769.000000 involved in 2735 hit(s)	= 13.02%
763.000000 involved in 2712 hit(s)	= 12.91%
861.000000 involved in 2690 hit(s)	= 12.81%
851.000000 involved in 2690 hit(s)	= 12.81%
768.000000 involved in 2383 hit(s)	= 11.35%
764.000000 involved in 2382 hit(s)	= 11.34%
765.000000 involved in 2180 hit(s)	= 10.38%
767.000000 involved in 2176 hit(s)	= 10.36%
852.000000 involved in 2154 hit(s)	= 10.26%
860.000000 involved in 2154 hit(s)	= 10.26%
766.000000 involved in 2112 hit(s)	= 10.06%
853.000000 involved in 1746 hit(s)	= 8.31%
859.000000 involved in 1746 hit(s)	= 8.31%
854.000000 involved in 1460 hit(s)	= 6.95%
858.000000 involved in 1460 hit(s)	= 6.95%
855.000000 involved in 1290 hit(s)	= 6.14%
857.000000 involved in 1290 hit(s)	= 6.14%
856.000000 involved in 1234 hit(s)	= 5.88%

Sharing with Commercial DAS

- Sounds Great! Ride along for free…or cheap?
- PIM shows up with 700PS and 700 Commercial
- Most DAS systems do not support 700PS and 700 Commercial
  - Filter needed between Tx and RX is too big
- 800 Mhz can be shared on some platforms
  - Amplifier Capacity is shared with 850 Celluar
- Commercial DAS covers WHOLE building
  - PS DAS is only needed for Coverage Fill In
- PS must meet CODE Requirements
  - Too Much battery needed for Shared system
  - NEMA 4 can be problem for Shared System
- Link Budgets are dramatically different
  - UL Amplifier Compression
  - Antenna Density for AWS 2100 MHz

Maintenance & Monitoring

- Latest Code Requires Both
  - Some Jurisdictions tying DAS to Fire Control Panel
  - Some retaining 3rd Party Vendors (ie. Longent…☺)

- Frequency Changes
  - Building Owners are responsible
  - Building Owners have no knowledge of issue.
    - Integrator should stay in touch with AHJ on regular basis.

FirstNet is Coming

- We Don't Know YET!
- Band Class (BC) 14
  - 10x10 MHZ of bandwidth has been dedicated to public safety in the prime upper 700MHZ frequency range
- AT&T has been chosen to build, operate, and upgrade FirstNet system
- Unclear how AT&T will role out Band 14 and how they will address in building
- **Link Budget for Firstnet is dramatically different from 700NB Radio**

http://www.firstnet.gov/
https://firstnet.nc.gov/

Key Take-Aways

- Insist on a Qualified Integrator
- Specify required channels (now and future)
- Specify minimum signal level and percentage of building coverage.
- Ask for Compliance Letter with Code specifics
- Ask for Capacity Calculation
- Ask for Coverage Predictions based on Capacity Calculation
- Specify Low PIM components and PIM / RL test results on Line Segments
- Ask for Post-Installation Coverage Mapping
- Sign up for Maintenance and Monitoring

Thank You!

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